THE WEATHER AND CIRCULATION OF OCTOBER 1955 [1]

A Month with a Double Index Cycle

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1. GENERAL CIRCULATION

The general circulation during October 1955 was characterized by four record-breaking index oscillations. During this period the 5-day mean zonal index, which expresses the strength of the average zonal westerlies between 35° and 55° N. in the Western Hemisphere, underwent two cycles, each with a period of approximately two weeks, as shown in figure 1. Inspection of the entire file (1941 to date) of index graphs revealed that the large amplitude and short period of this month's index fluctuations were unique. A similar change took place in October 1946, but then only one cycle occurred with a maximum variation of 5.2 m. p. s. This October's index, which was initially near normal, was subjected to weekly changes of as large as 6 to 7 m. p. s. There were periods of both high and low index as the circulation fluctuated back and forth between fast zonal and strong meridional flow.

At the beginning of October temperate-zone westerlies were fast at all longitudes. The first diminution occurred in the Atlantic and then, over a period of weeks, migrated upstream to affect the Pacific during the final week of October. This westward movement was irregular and it often appeared that a rather well matched "tug-of-war" existed between the initially fast westerlies in the Pacific and the blocking phenomenon in the Atlantic. Ultimately the low index regime dominated the circulation and set the stage for below normal westerlies during the entire month of November. Associated with these index changes were very different short-period mean circulation patterns which warrant some discussion.

700-mb. 5-day mean charts, figure 2, were selected to correspond with the maxima and minima of the index cycles, which were one week apart, and to illustrate the changes and extremes in the circulation that occurred during this month. The mean flow for October 8–12 (fig. 2A) was essentially one of high index over the entire Northern Hemisphere. In the Western Hemisphere the index of 13.1 m.p.s. was the highest 5-day mean value of the month. Downstream from the confluent pattern in the western Pacific the westerlies were concentrated into a very narrow jet stream. The waves were long and of small amplitude. The closed anticyclone in the Davis Strait, which originated early in the month, is particularly noteworthy because of its persistent nature and because of its future effects on the circulation and weather.

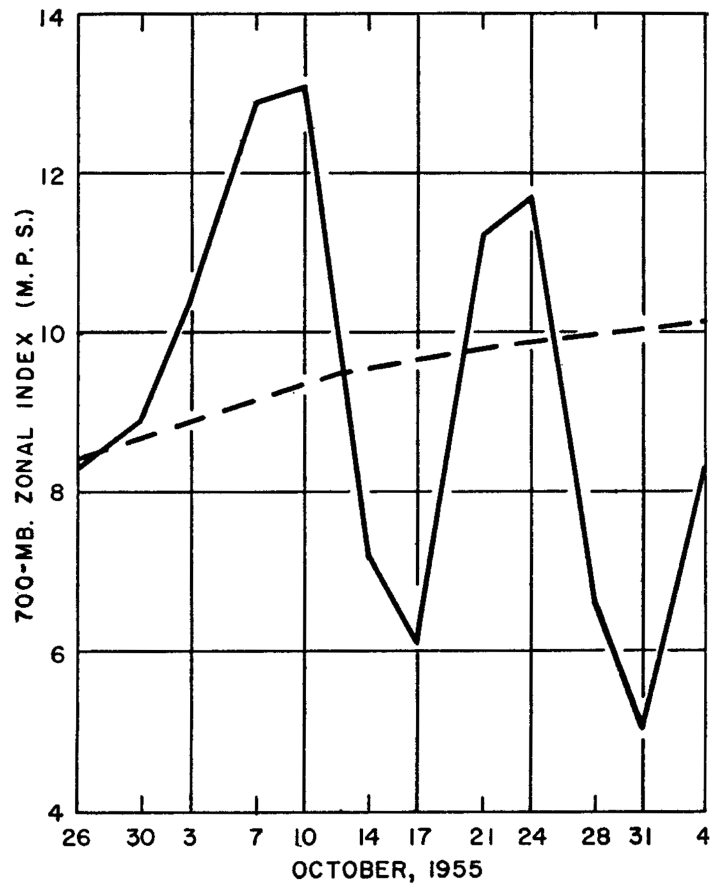


FIGURE 1.—Time variation of temperate-latitude zonal index (average strength of zonal westerlies in meters per second between 35° N. and 55° N.) at 700 mb. over the Northern Hemisphere from 0° westward to 180° longitude. Solid line connects 5-day mean zonal index values (plotted at middle of 5-day periods) for October. Dashed line shows variation of normal zonal index values. Note the unprecedented double index cycle.

One week later, October 15–19 (fig. 2B) at the minor index minimum (6.1 m. p. s.), a rapid, intense breakdown and amplification of the circulation occurred. Some decrease in wind speed was apparent in the Pacific, but the largest changes were downstream in the United States and Atlantic. The intensifying anticyclone in the Greenland region was accompanied by southward displacement

[1] See charts I–XV following p. 247 for analyzed climatological data for the month.

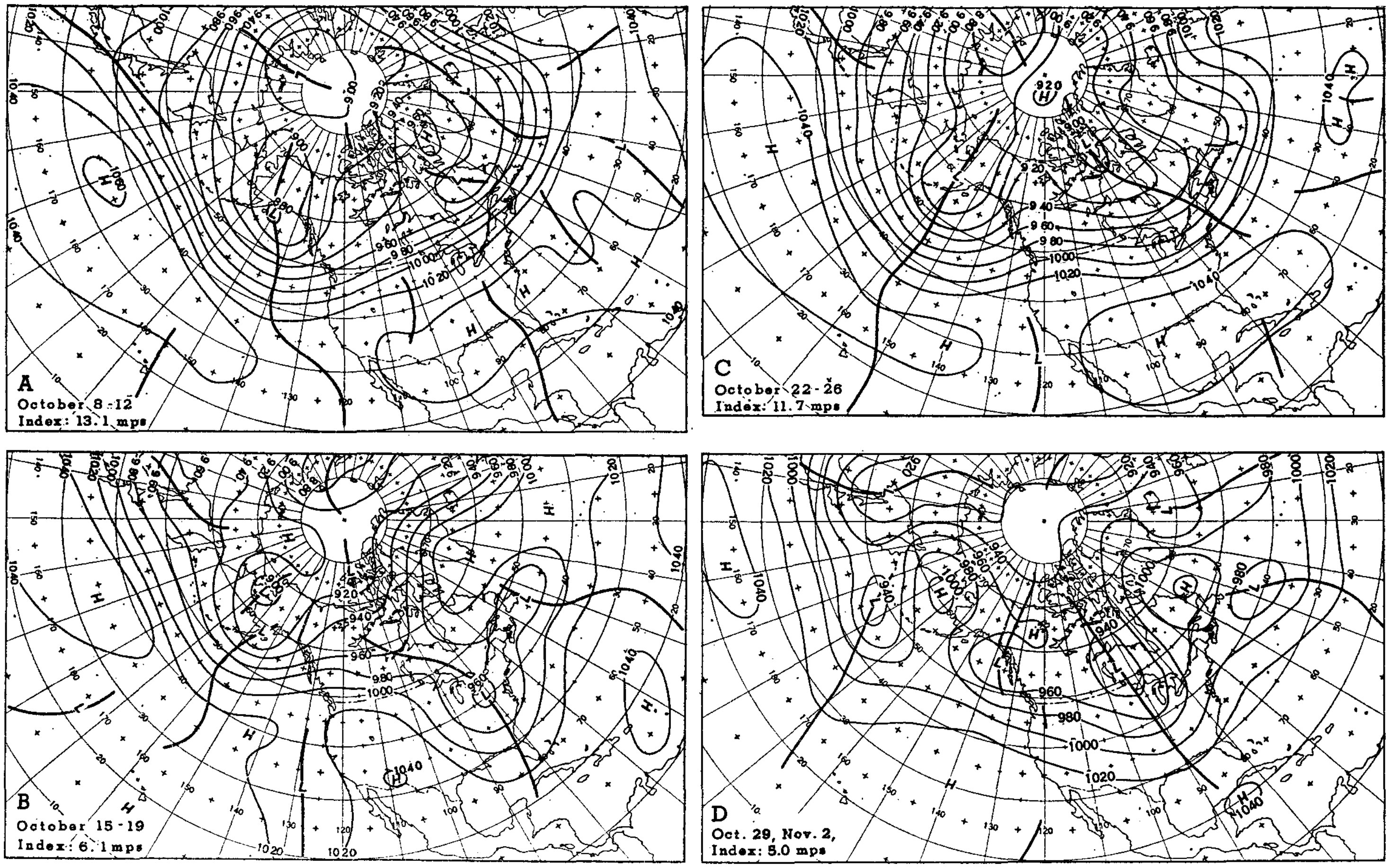


FIGURE 2.—Five-day mean contours at 700 mb. (in tens of feet) for four periods one week apart which correspond to the maxima and minima of the double index cycle (fig. 1). Intense, weekly oscillations were characteristic of October 1955.

of vigorous cyclonic conditions into Europe and eastern North America. Associated with this Atlantic blocking pattern was the short wave length which resulted from the addition of a new major trough in the Atlantic. The waves were generally stationary or retrogressive.

The zonal westerlies (index of 11.7 m. p. s.) again dominated during the period October 22–26 (fig. 2C) and the description of the earliest mean chart (fig. 2A) generally applies except that the jet stream was less concentrated. In the Atlantic and eastern North America the vortical pattern of the previous week was replaced by the eastward march of the strong westerlies, but weak blocking was still discernible. 700-mb. mean heights ranged up to 360 feet above normal in the Davis Strait and down to 230 feet below normal just east of Labrador. There was a decrease in wave number as the Atlantic trough filled. General progression of the troughs prevailed.

The minimum low index (5.0 m. p. s.) regime of the month was October 29–November 2, (fig. 2D). There was a major breakdown of the zonal flow into numerous vortices and truncated troughs. This time, in contrast to two weeks prior, the westerlies decreased farther upstream in the Pacific, where a strong blocking High now appeared in the Bering Sea.

It now has been emphasized that two basic regimes existed in October. If the monthly mean circulation is divided into two 15-day means, the predominating regimes of the semi-months are brought into focus. The first half, October 1–15 (fig. 3A) represented mostly the high index regime (11.0 m. p. s.), especially in the Pacific where a stronger than normal westerly flow was observed east of the confluence zone along the Asiatic coast. The positive 700-mb. height anomaly in the Pacific was firmly established in August [1] and has been a long-period cornerstone of the general circulation. In eastern North America mean heights were above normal, with the maximum anomaly in the Davis Strait. Anticyclonic flow existed along the eastern seaboard.

During the latter half month, October 16–30 (fig. 3B) the low index (average 8.6 m. p. s.), blocking regime predominated. The general circulation responded in typical fashion to the persistent positive anomaly in the Greenland area as major 700-mb. height falls occurred to the south over the eastern United States, Labrador, and European areas. The unusual cyclonic conditions over Europe and the strong, northerly anomalous flow produced some abnormally early freezing weather.

Even though large fluctuations occurred during the

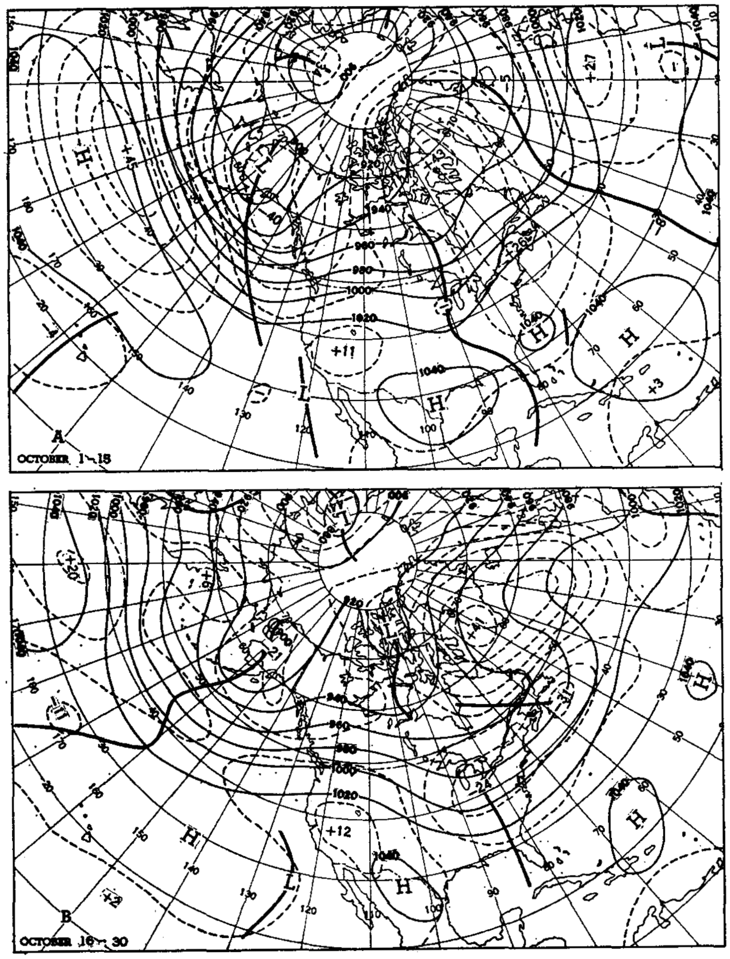


FIGURE 3.—Fifteen-day mean contours and height departures from normal at 700 mb. (both in tens of feet) for periods (A) October 1–15, 1955 and (B) October 16–30, 1955. Heights continued above normal in western United States and Greenland region but fell away in eastern United States. High index dominated first half-month, low index the latter half.

month there were also persistent features which were outstanding in the monthly mean 700-mb. height (fig. 4). Above normal heights in the Pacific at middle latitudes, coupled with subnormal values over eastern Siberia and Alaska, resulted in a high index circulation in the Pacific. This contrasted with the blocking regime in the Atlantic sector, where heights averaged above normal from the Greenland area to southern New England and below normal over the central Atlantic and the eastern United States.

The spatial distribution of the 700-mb. monthly mean wind speed and anomaly (fig. 5) shows that the fastest winds, greater than 20 m. p. s., were in the central Pacific, while a somewhat weaker and more diffuse flow existed over the United States and the Atlantic. A northward displacement from normal of the Pacific wind maximum produced zonal bands of above and below normal winds. In the United States a greater than normal southward displacement of the westerlies, which had been abnormally far north throughout the summer [1], was representative of the blocking regime which got underway in October. Stronger than normal winds were observed over central United States, but wind speeds were weak in eastern Canada and the western Atlantic where they are normally a maximum.

Several investigations, for example [2, 3], have associated dynamic instability, which would lead to a breakdown of the zonal flow into vortices, with the shear of the westerlies. This month the maximum north-south wind shear at 700 mb. for the Western Hemisphere occurred on the 9th and was associated with the peak daily index of the month. Zonal wind speed profiles for this day are shown in figure 6. Even though taken over a large longitudinal band (0° westward to 180°), the north-south shear was extreme. However, it did not meet the familiar criterion for instability (anticyclonic shear equal to or greater than the Coriolis parameter). At 700 mb. (1500 GMT), (fig. 6A), the maximum anticyclonic shear was approximately 10^{-5} per second between 35° and 45° N., and the cyclonic shear was 0.2×10^{-4} per second between 55° and 65° N. At the 200-mb. level, (0300 GMT) figure 6B, the maximum shear values were approximately the same as those at the 700-mb. level. Wind speeds were 10 to 12 m. p. s. faster at the upper level, and the average vertical wind shear between the two levels exceeded 10^{-3} sec^{-1}. If smaller areas had been considered, greater shear values undoubtedly would have been found. The highest shear was apparently in the Pacific with weaker values in the United States and Atlantic.

2. WEATHER AND CIRCULATION IN THE UNITED STATES

In the United States the circulation pattern became progressively more anticyclonic in the West and cyclonic in the East from September [4] through October. In some areas there was even a change from September to October in the sign of the relative vorticity at the 700-mb. level and the pressure departure from normal at sea level (Chart XI, inset). Therefore the departure of monthly average temperature from normal (Chart I-B), showed little month-to-month persistence except for two small areas: (1) a warm region spreading south-southwestward from Wyoming, and (2) a region of subnormal temperatures in the far Northwest, where small areas have experienced cooler than normal weather for nine consecutive months.

It is interesting that, in spite of the existence of two regimes in October, the monthly mean flow (fig. 4) generally determined the weather over the United States. After the first week, which was warm in the Southeast, there was little variation in the country's temperature, and each weekly anomaly resembled the monthly mean. However, New England experienced some extremely variable weather. For example, Boston, Mass., reported a record-breaking maximum temperature of 82° F. on the 11th, but frost on the 23d.

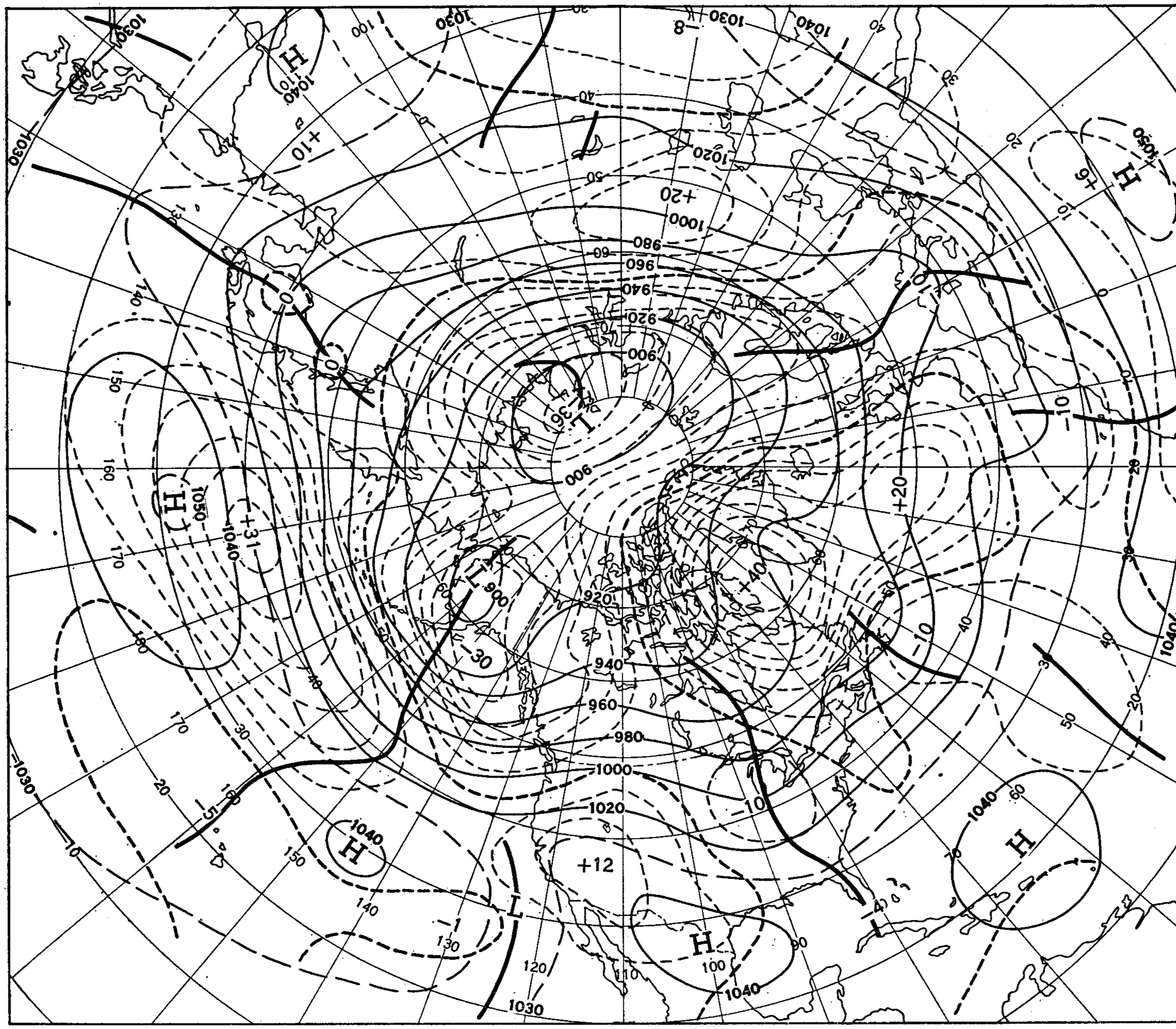


Figure 4.—Mean 700-mb. contours and height departures from normal (both in tens of feet) for October 1955. Persistent above normal heights in the mid-Pacific and Davis Strait were prominent features of the general circulation. Anticyclonic and cyclonic conditions prevailed in western and eastern United States respectively.

Throughout most of the western mountains, where the circulation was anticyclonic and 700-mb. height departures were positive, temperatures averaged above normal. The maximum anomaly (+6° F.) was observed in Montana where the foehn effect was most pronounced. The observed temperatures of 92° F. on the 10th at Glasgow, 82.5° F. on the 18th at Billings, and 76.6° F. on the 25th at Helena were new highs for that late in the fall. Few polar anticyclones formed in the Canadian source region, where mean sea level pressure anomalies were negative (Chart XI, inset), and Canadian polar outbreaks were scarce and weak (Chart IX). This absence of polar air masses contributed to above normal temperatures in the northern tier of States east of the Continental Divide. On the other hand, there were frequent intrusions of polar Pacific air into southeastern States, where Pacific air was cool enough to produce subnormal temperatures, especially under the existing cyclonic flow. Augusta, Ga., where the maximum negative anomaly was observed, equalled its minimum temperature record of 38° F. on the 20th.

Little rainfall (Charts II and III) was observed in most parts of the Southwest and Great Plains, where the 700-mb. mean flow was anticyclonic. Southern California

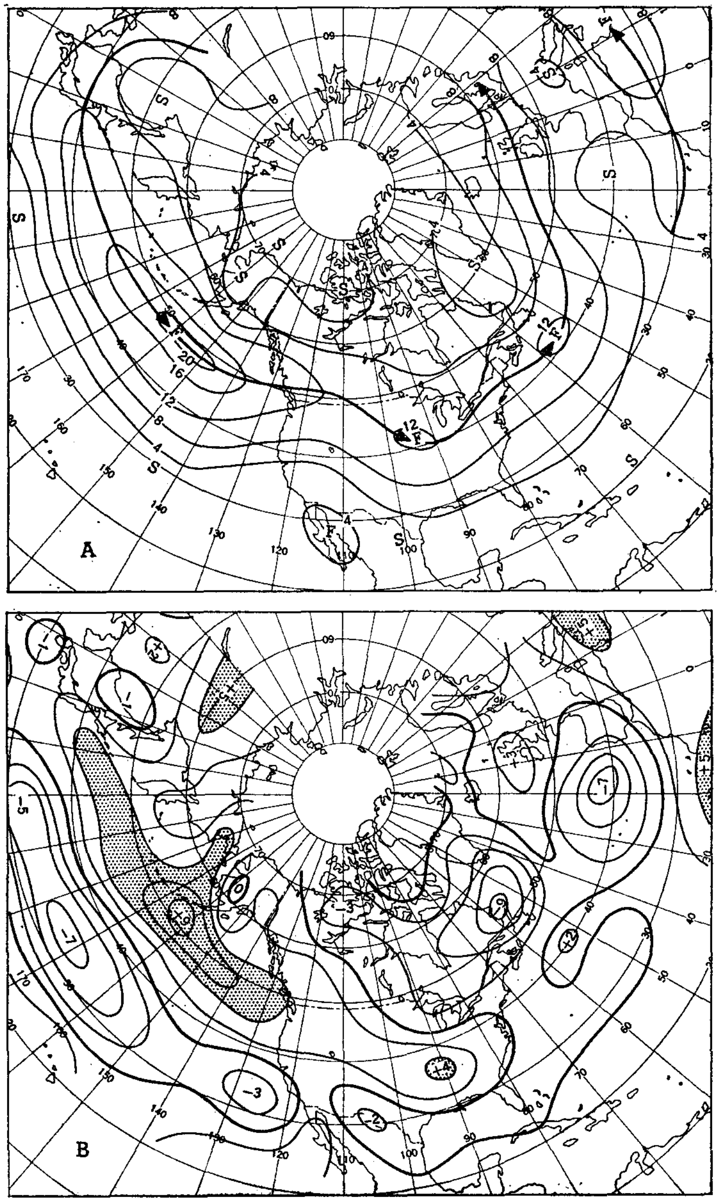


FIGURE 5.—(A) Mean 700-mb. isotachs and (B) departure from normal wind speed (both in meters per second) for October 1955. Solid arrows in (A) indicate position of mean 700-mb. jet axes. The jet was strong and north of normal in the Pacific, weak and south of normal in the United States.

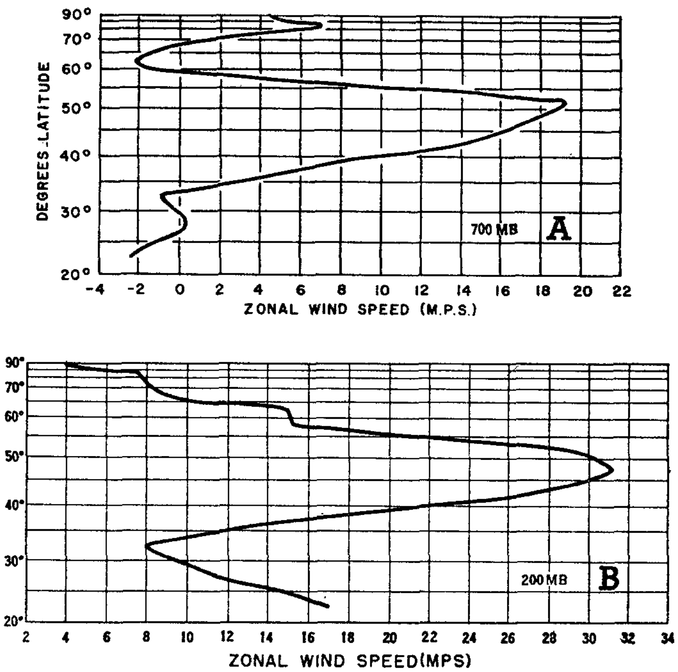


FIGURE 6.—(A) 700-mb. and (B) 200-mb. zonal wind speed profiles in the Western Hemisphere for October 9, 1955. Strong speeds and shears preceded the collapse of the westerlies.

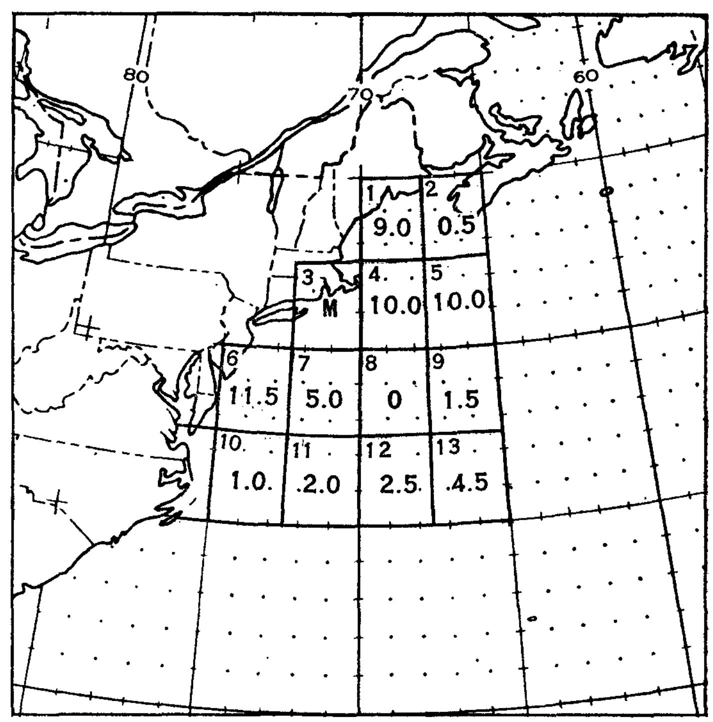


FIGURE 7.—Mean sea surface temperature departures from normal (to tenths of a degree F.) by 2½° squares for October 4–13, 1955. No observations were available in square numbered 3 (number in upper left hand corner). Anomalies were positive in all sectors and especially large along the coast.

and parts of Utah and Arizona received no measurable precipitation. Heavy rains occurred in the Northwest as stronger than normal southwesterly flow of moist Pacific air crossed the mountain ranges. The mean trough in the eastern United States was accompanied by copious precipitation to its east. Considerable rain was also observed west of this trough. During the blocking periods, Gulf and Atlantic moisture curved cyclonically around the slow, northward moving daily Lows (Chart X), and precipitation fell well to the west of the cyclone centers. Early in the month, October 2–4, floods occurred in Oklahoma and heavy rain fell in parts of Texas as moist Gulf air masses replaced the cool air from the Pacific. Later, October 28 and 29, a cold front from the Pacific with its forerunning squall line produced severe thunderstorms and tornadoes in northern Louisiana and Mississippi.

Southern New England, and New York, which were still recovering from the August disaster [1] suffered another serious flood October 14–16. This October flood occurred during a period of strong blocking in eastern United States. A stagnant 700-mb. Low, blocked by a strong High to its northeast, was located west of Pennsylvania, and southerly, cyclonic flow favorable for heavy precipitation persisted over the flooded areas (see fig. 2B). (This situation has been treated in detail by Winner and Ross elsewhere in this issue.) Boston experienced its wettest October in 23 years, and Pittsfield, Mass., reported a new precipitation record, 7.04 inches, for this month.

In the August issue of this series [1] it was suggested that the anomalously warm ocean water off New England might have contributed to the extremely heavy rainfall associated with hurricanes Connie and Diane. Since this region again received copious rainfall, a spotcheck of the ocean-surface temperatures for the 10 days just prior to the floods was made in a manner similar to the August investigation. There were no negative anomalies observed, and near the coast temperatures were as much as 10° F. above normal, as shown in figure 7. Furthermore, during the entire period of heavy rain there was a strong easterly onshore flow over this warm water (see Daily Weather Maps for October 14–16, 1955).

REFERENCES

1. J. Namias and C. R. Dunn, "The Weather and Circulation of August 1955—Including the Climatological Background for Hurricanes Connie and Diane," *Monthly Weather Review*, vol. 83, No. 8, August 1955, pp. 163–170.
2. J. Bjerknes, "Extratropical Cyclones," *Compendium of Meteorology*, American Meteorological Society, Boston, Mass., 1951, pp. 577–598.
3. J. M. Van Meighem, "Hydrodynamic Instability," *Compendium of Meteorology*, American Meteorological Society, Boston, Mass., 1951, pp. 434–453.
4. A. F. Krueger, "The Weather and Circulation of September 1955," *Monthly Weather Review*, vol. 83, No. 9, September 1955, pp. 206–209.

Weather Notes

(*Continued from p. 224*)

The Earl Bennett farm is located about 2½ miles north-northeast of the Post farm. Mr. Bennett was roused from bed between 10:05 and 10:10 p. m. Wednesday by hail, some as large as hen's eggs, which fell covering his yard. This was accompanied by severe and constant lightning. Then the storm struck, destroying several outbuildings. This was followed by a lull which lasted half a minute. Strong winds again struck suddenly (direction of winds unknown) but apparently with no further damage. Looking out to the north, Mr. Bennett saw the tornado funnel which was back-lighted by constant lightning farther to the north. He described the funnel as hanging down from a black cloud and gyrating slowly back and forth. He estimated it to be about a quarter of a mile in diameter in its lower portions. From the pattern of destruction of the Bennett farm it was not possible to deduce the direction of winds causing the damage. Debris which was carried as far as a mile to the north-northeast was relatively light in weight and was probably carried in the vortex.

Both of these accounts seem to indicate that the tornado funnel was on the trailing edge (south-southwest) of the parent thunderstorm itself, the parent thunderstorm being identified by the hail and severe lightning. Both accounts identified a quiet lull lasting for a minute or less between two storm surges suggestive of an "eye." In one case destruction occurred after the lull and in the other case before the lull. Neither eyewitness reported any sensation of change in pressure, having been questioned on that specific point. Both accounts indicated the absence of heavy rain accompanying the parent thunderstorm or the tornado, referring to the rain as "light."

Oxford, Kans.—A tornado struck just north of Oxford, Kans., about 2220 CST doing considerable damage, completely destroying several sets of farm buildings and killing five children from one family. Little information of meteorological significance is available from this area. One witness reported an automobile going "straight up" and being deposited eastward several hundred yards from its initial position.

Udall, Kans.—Udall, Kans., about 30 miles southeast of Wichita, underwent almost complete destruction from the tornado which struck about 2235 CST. Motorists were reported to have seen the tornado funnel approaching Udall. It struck the southwest corner of the town first, traveling almost due northeast with destruction occurring over the entire width of the town, about three-fourths of a mile. The only habitable structure left in town was a frame dwelling with only minor damage on the extreme northwest edge of town. Except for a few other dwellings in the northwest corner of town which were twisted, moved, and badly damaged, the only buildings in town not completely leveled were a few two-story masonry buildings from which the upper story had been removed. There was evidence of rotation although it was confused somewhat by the pattern of light-weight debris, much of which indicated a southwest to northeast flow. It was not uncommon, for instance, to see a large tree having fallen to the southwest, and a large piece of tin wrapped around a smaller nearby tree with its free edges pointing northeastward, obviously having been carried by a southwest wind. Destruction requiring immense forces however did yield indications of cyclonic rotation. A municipal water tower in the northwest part of town was toppled toward the southwest. The center of rotation passed across and at almost right angles to a train of railroad cars on a railroad siding. The cars to the northwest of the center were blown off the tracks to the southwest and the cars to the southeast of the center were blown to the northeast, although some cars between (over a distance of about 1½ city blocks) were still on the tracks.

Some evidence was found of "explosive" effects. A concrete block building about 30 feet by 40 feet stood in the southwest part of town and was apparently near the path of the center of the tornado. All four walls had fallen outward, leaving the floor area relatively clear of debris.

Eyewitness accounts were not available from Udall until several days afterward because of understandable confusion and the shock that most survivors suffered. Wheeler Martin, a survivor from Udall, reported that there was a "roaring noise" at about 2220 CST followed by hail and rain. The wind was from the southwest and getting stronger. After a few minutes, the house began to shake. At 2235 CST it "collapsed." The hail continued for several minutes.

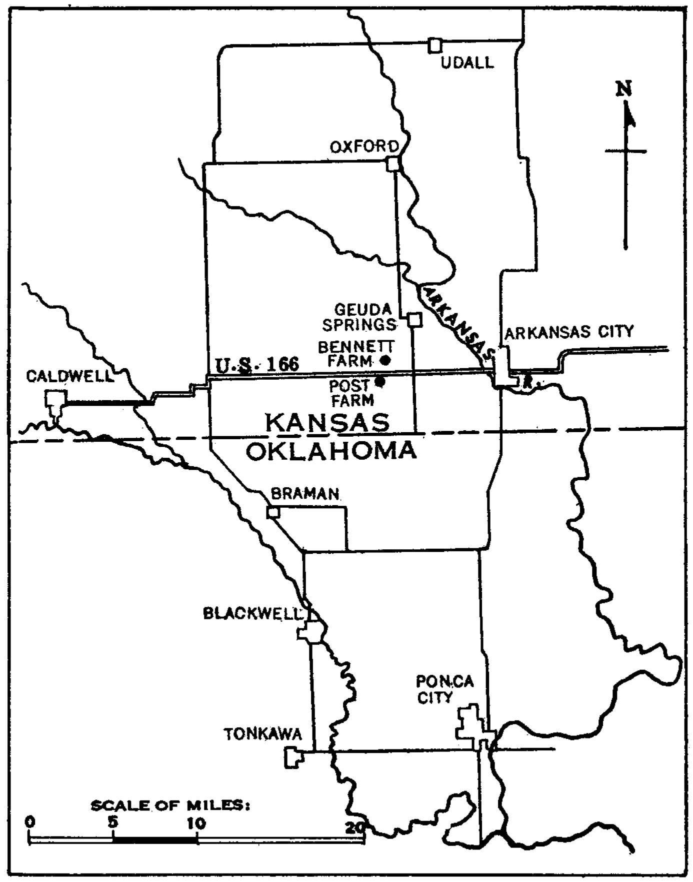
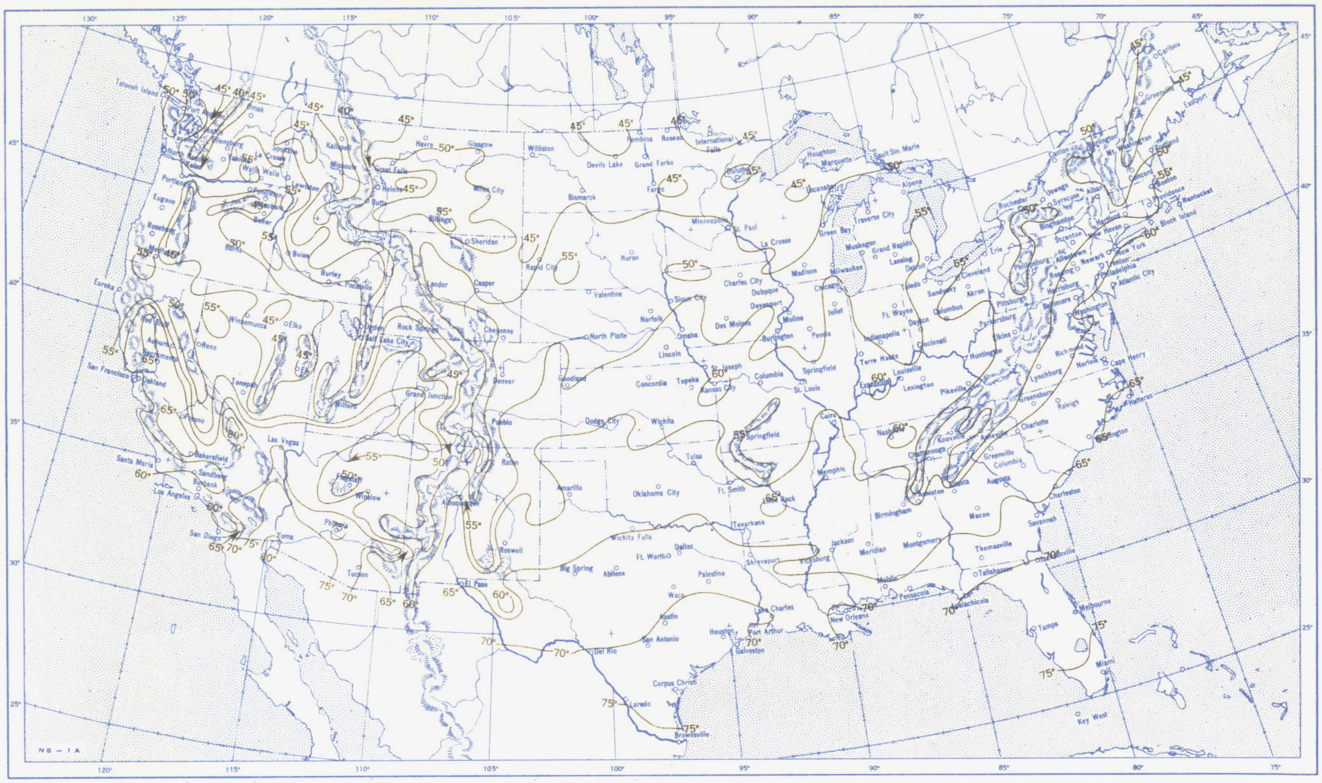


FIGURE 1.—General location map for Blackwell, Okla.-Udall, Kans., tornadoes, May 25, 1955.

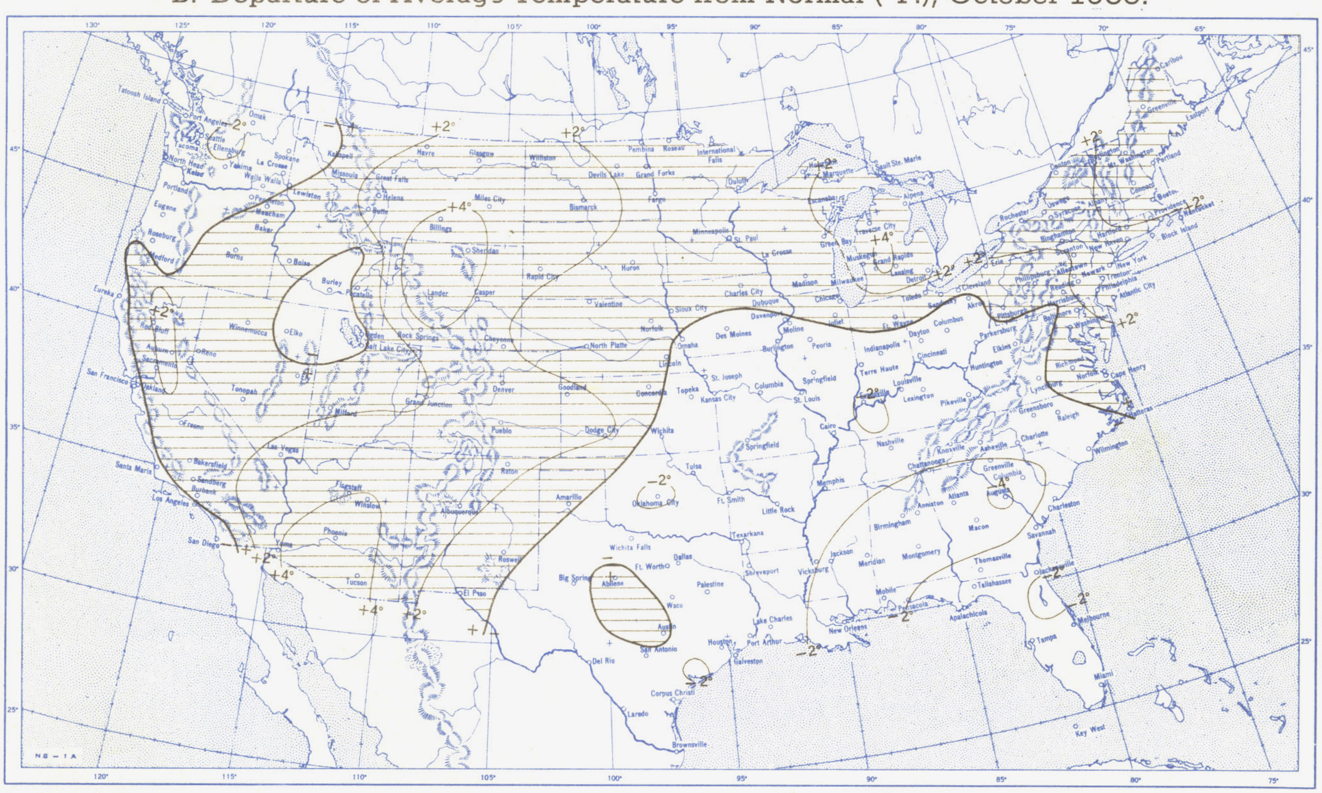
Beyond Udall, the path of major destruction ended. Spotty damage extended for 18 miles east-northeast of Udall.

A carefully conducted survey of damage accomplished by one of the authors Mr. Phillips revealed almost positive indications that at least from the time the tornado crossed U. S. Highway 166 and throughout its northward traverse through Udall, a continuous path of destruction was apparent. There was some "skipping" but the greatest skip was on the order of 3½ miles.—*Victor V. Phillips, MIC, WBAS, Wichita, Kans.; Joseph G. Galway, SELS Center, Kansas City, Mo.; and Donald M. Hanson, District Forecast Center, Kansas City, Mo.*

Chart I. A. Average Temperature (°F.) at Surface, October 1955.

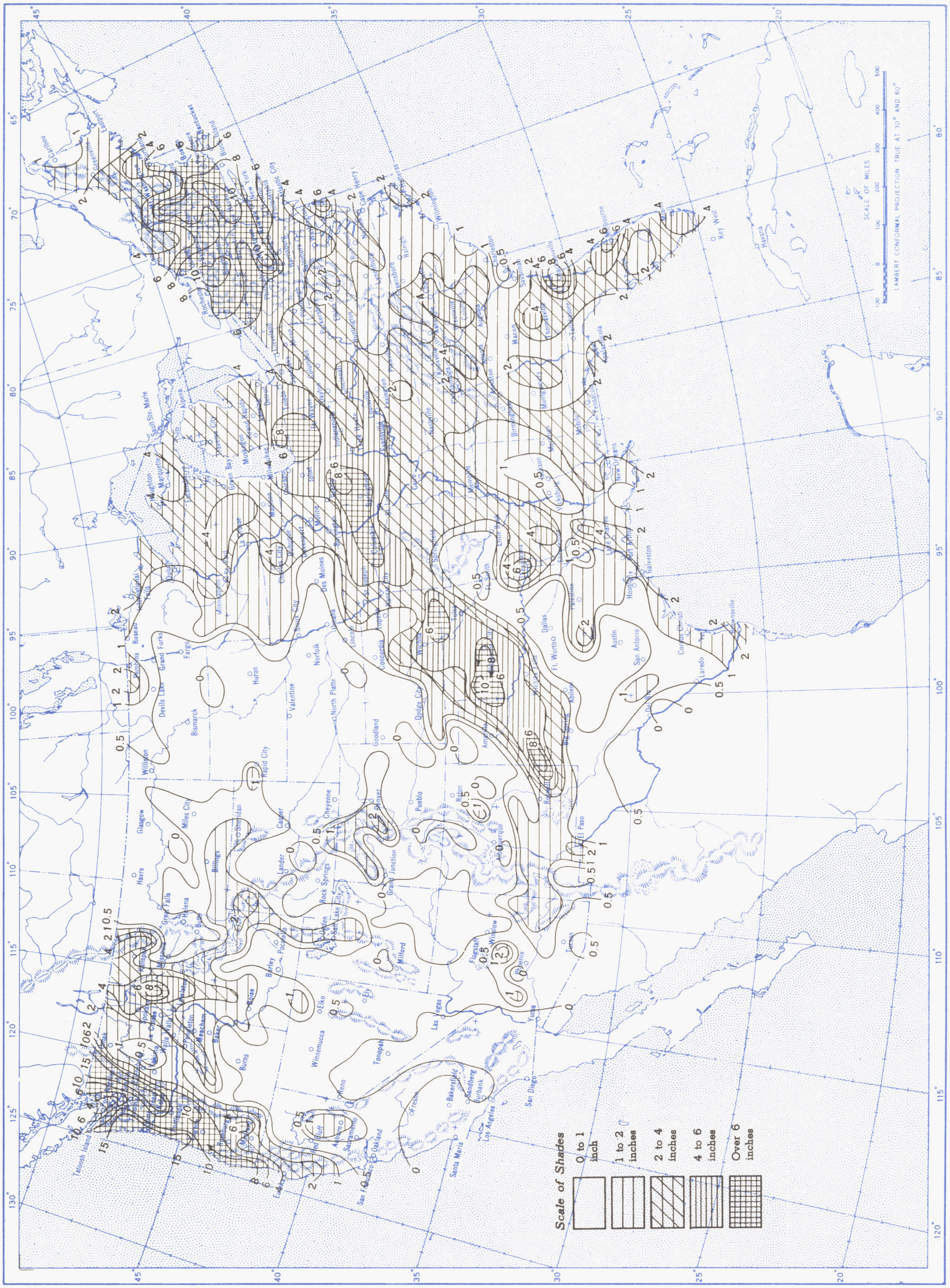


B. Departure of Average Temperature from Normal (°F.), October 1955.



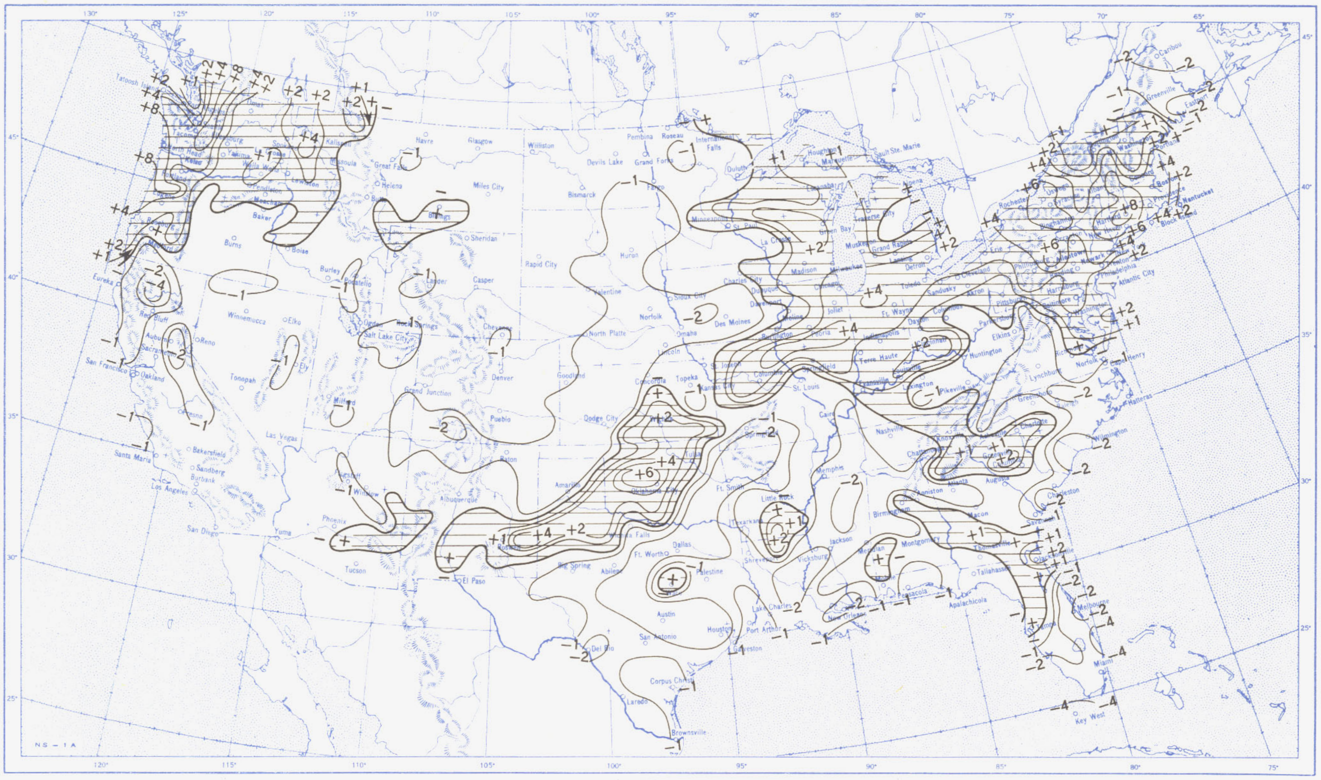
A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

Chart II. Total Precipitation (Inches), October 1955.

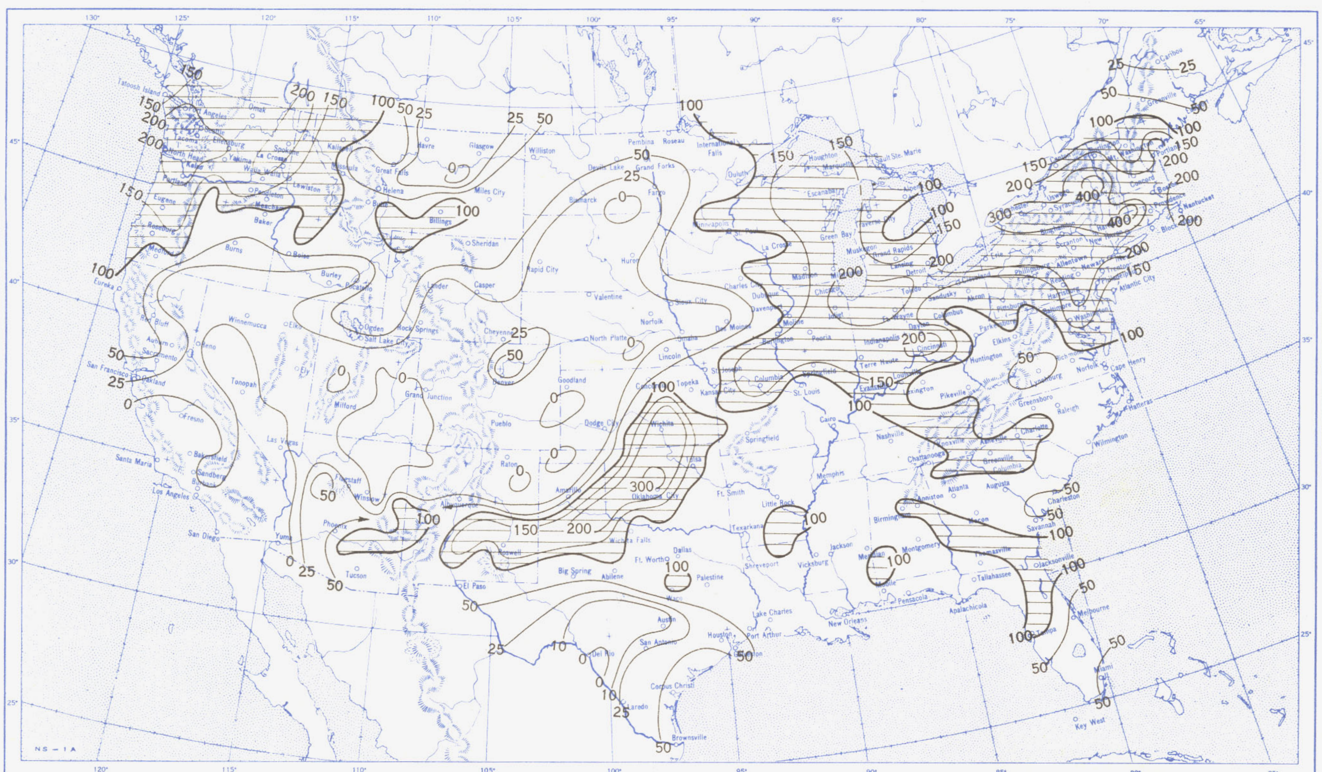


Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), October 1955.

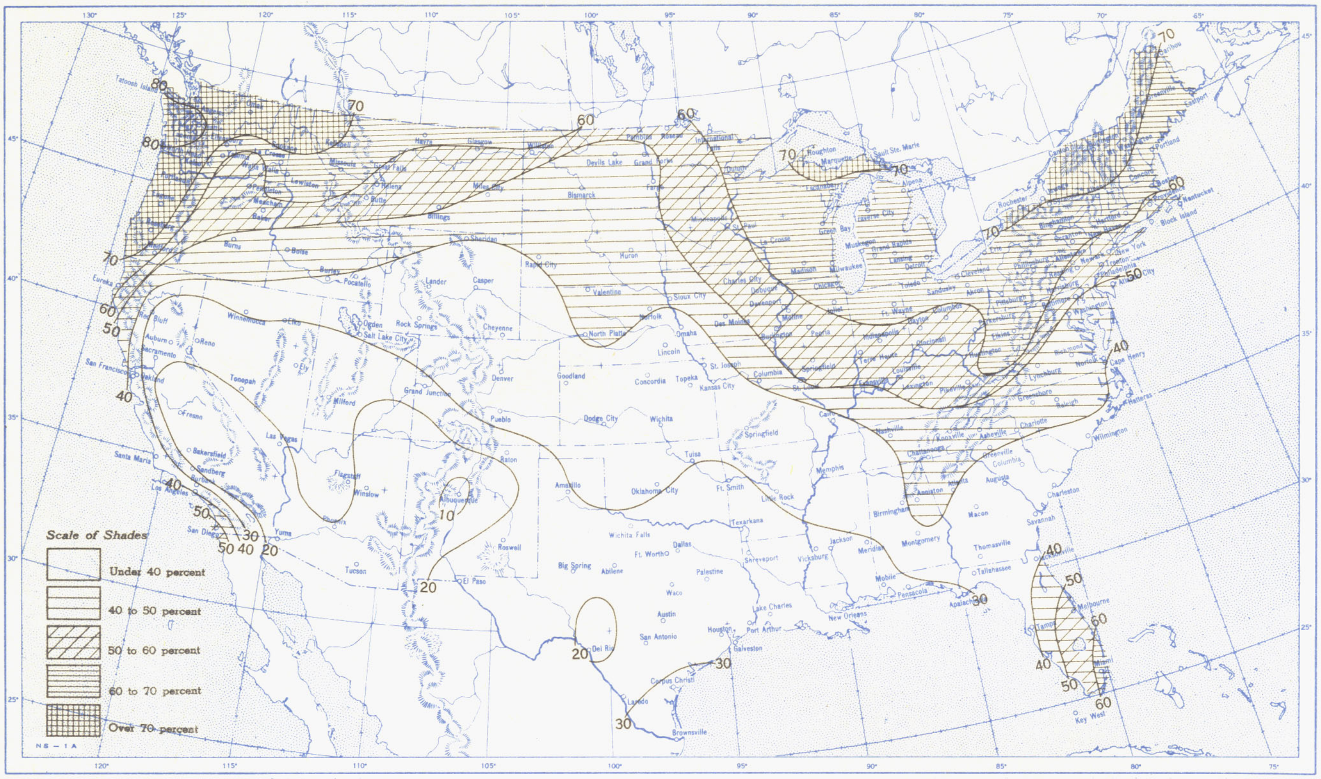


B. Percentage of Normal Precipitation, October 1955.

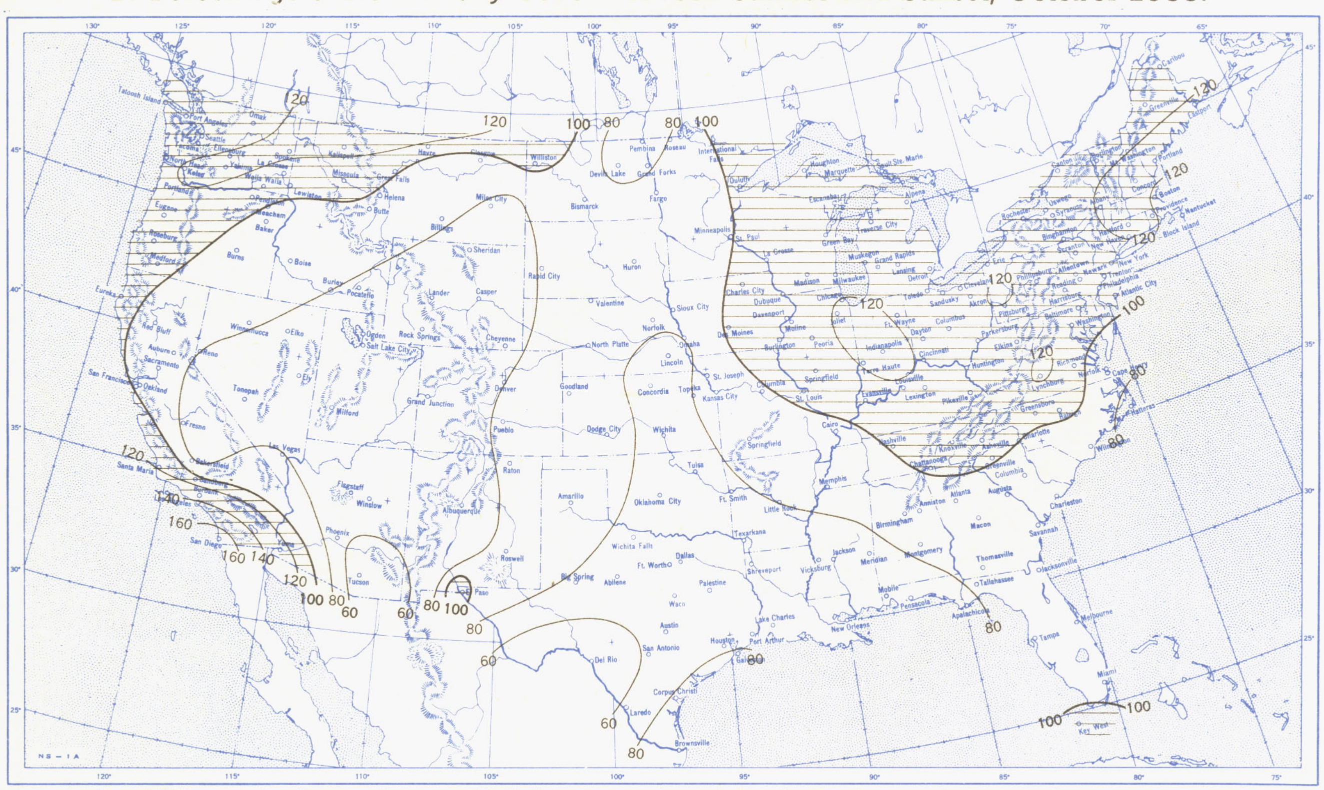


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, October 1955.

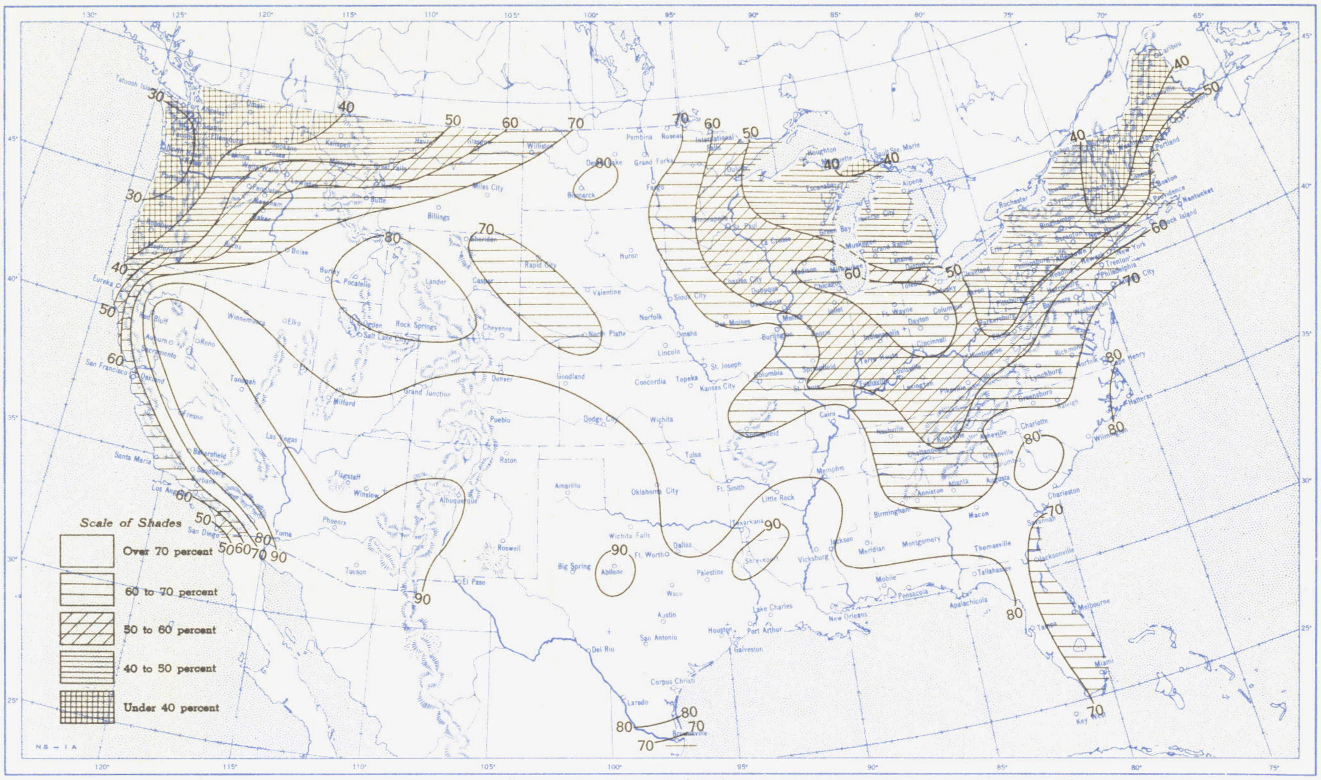


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, October 1955.

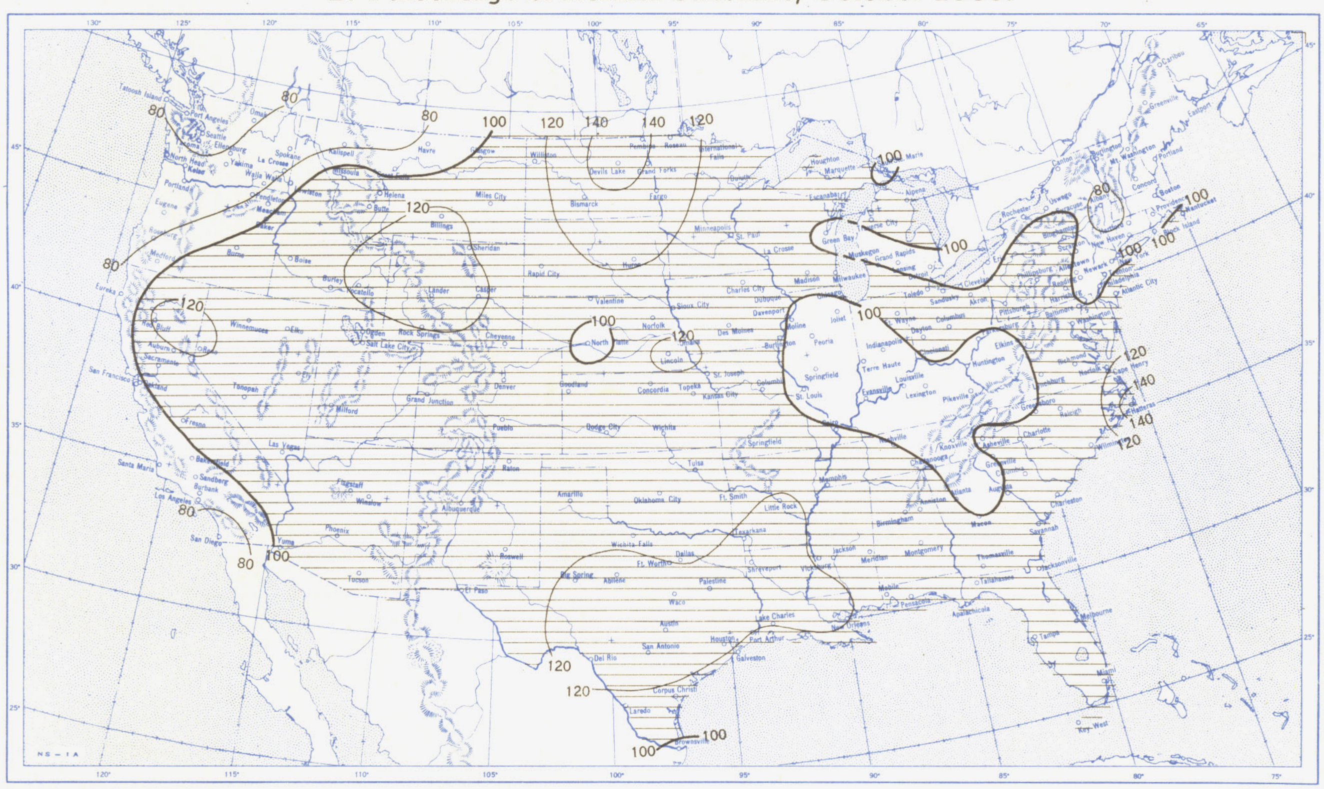


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, October 1955.



B. Percentage of Normal Sunshine, October 1955.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, October 1955. Inset: Percentage of Normal Average Daily Solar Radiation.

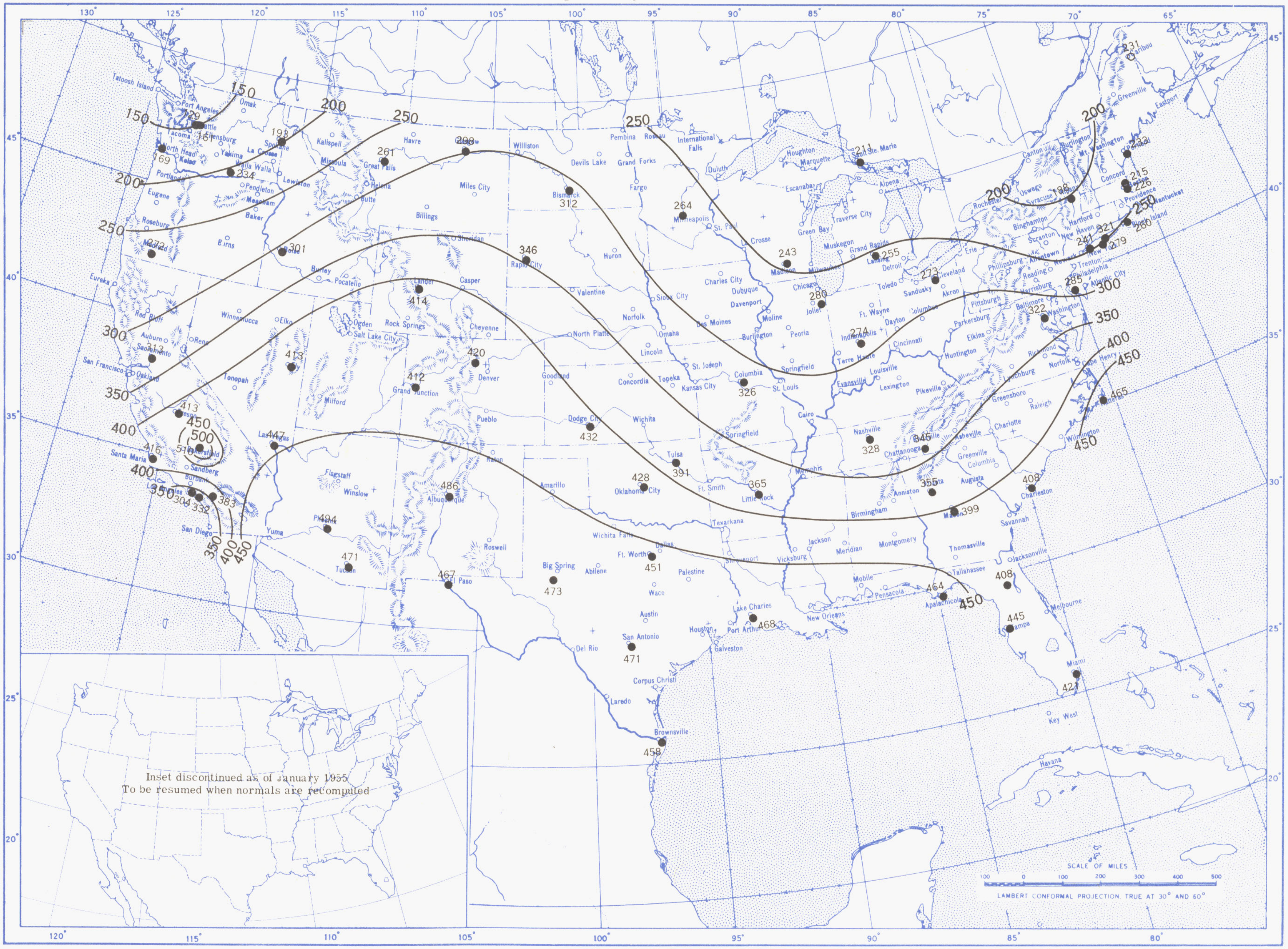
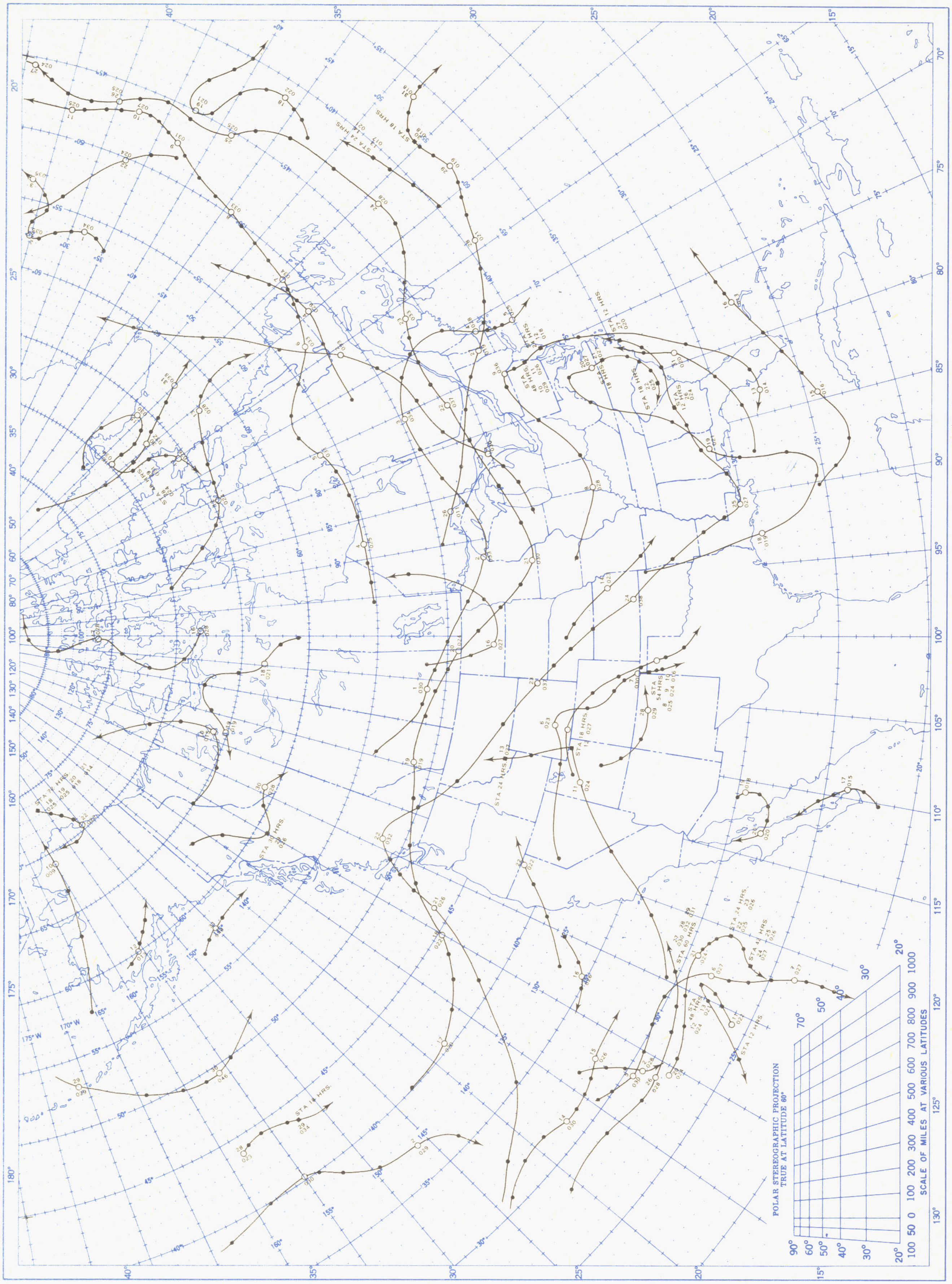


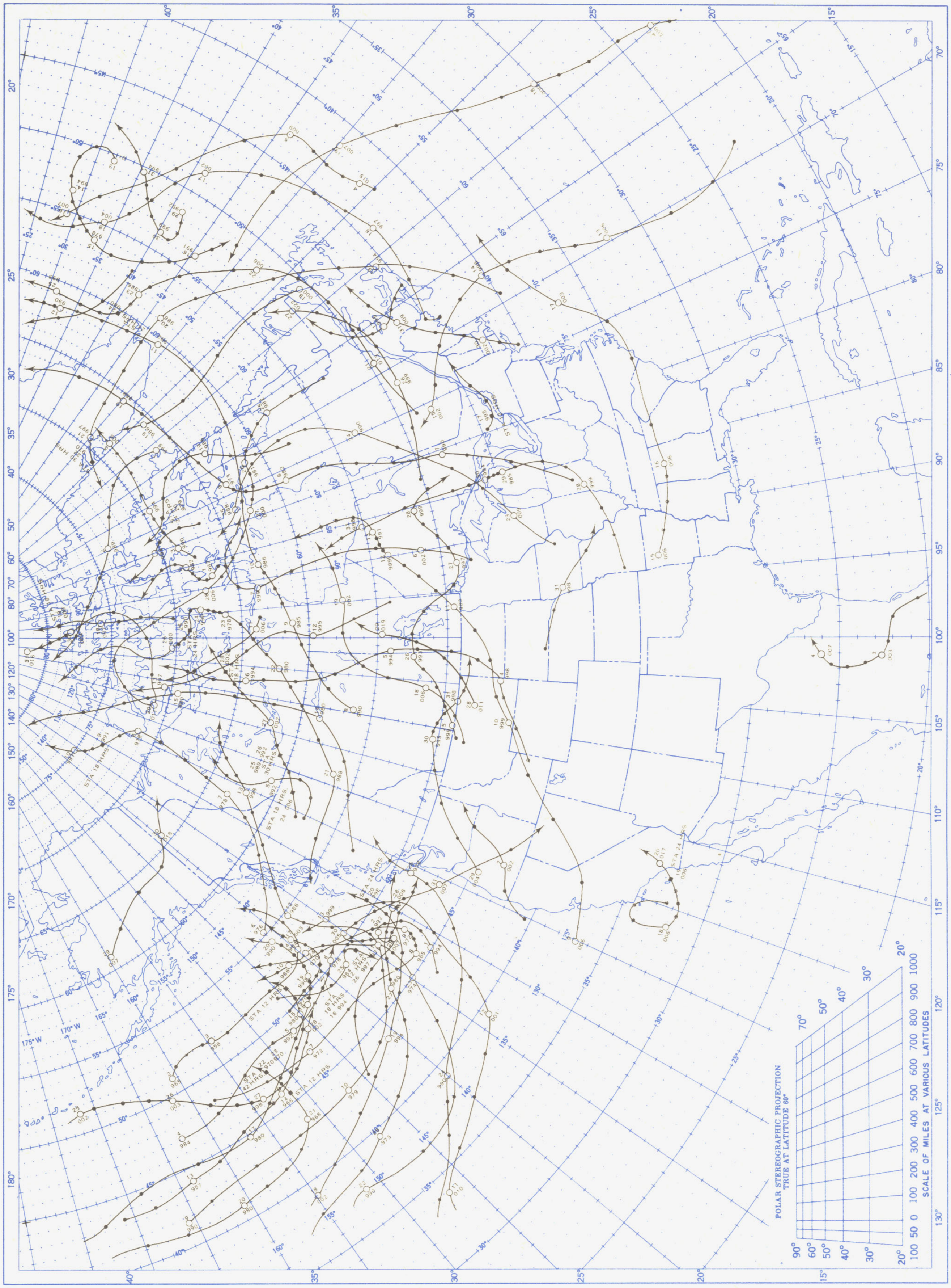
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, October 1955. (Corrected)



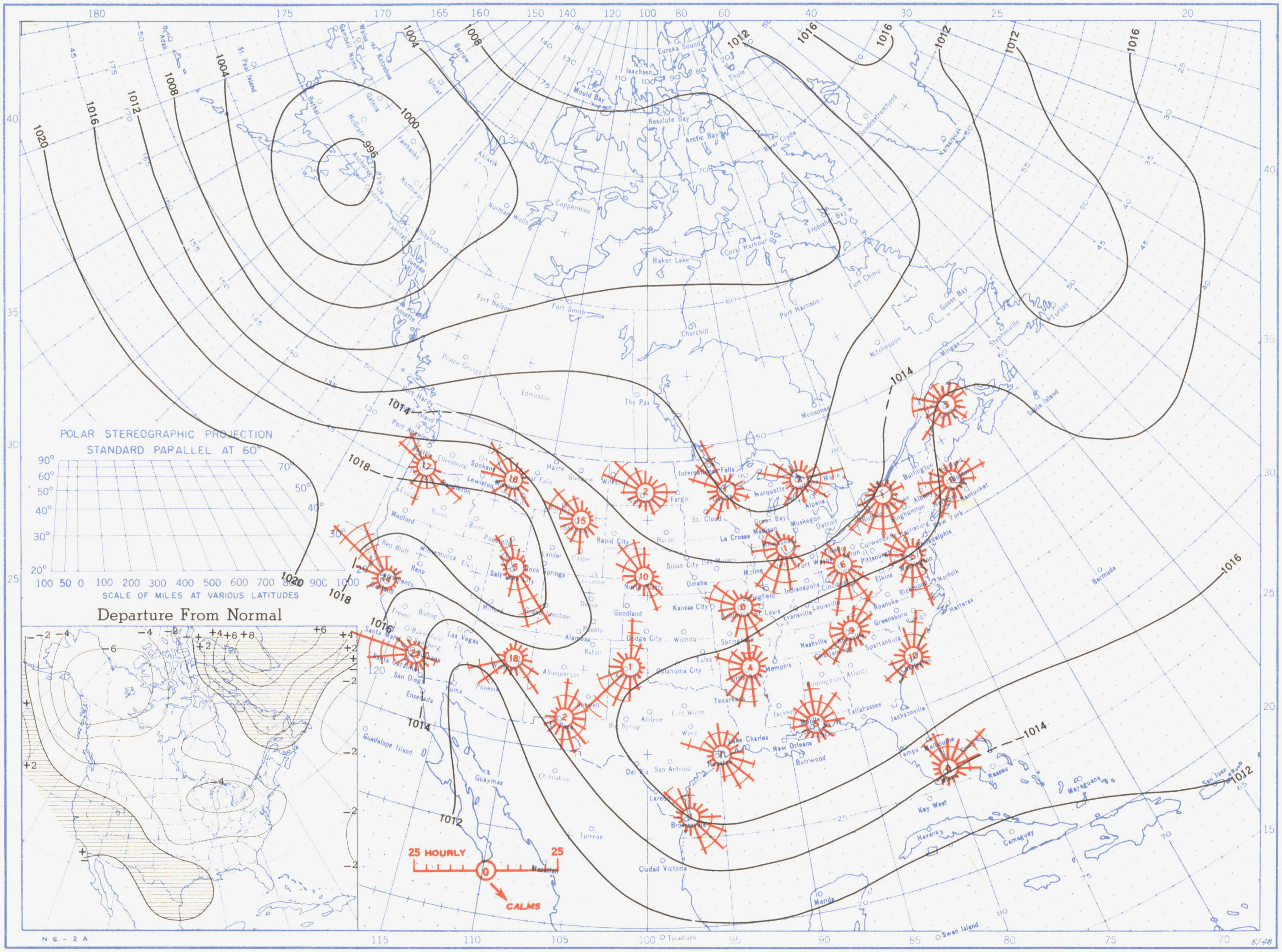
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, October 1955. (Corrected)



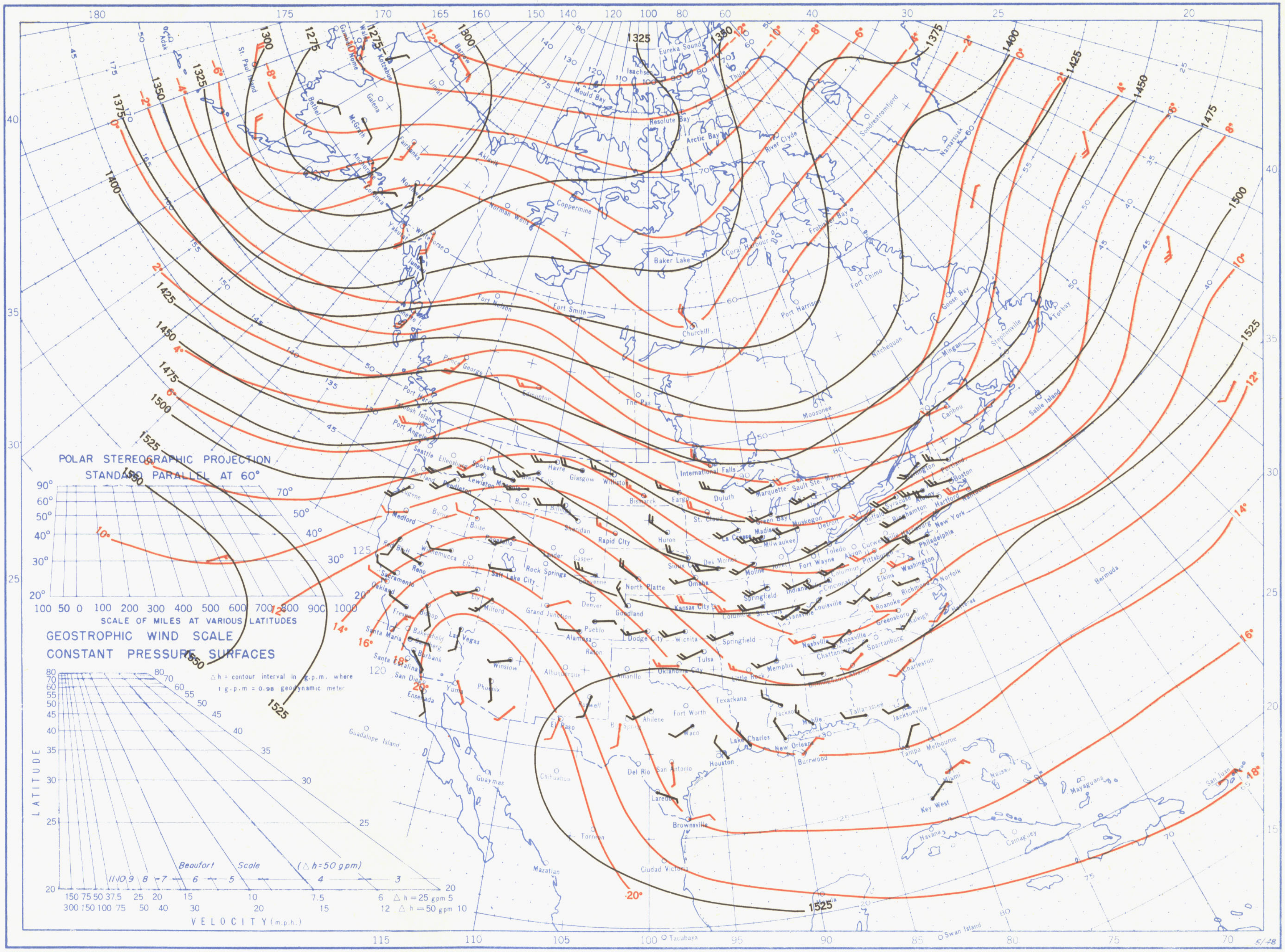
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, October 1955. Inset: Departure of Average Pressure (mb.) from Normal, October 1955.



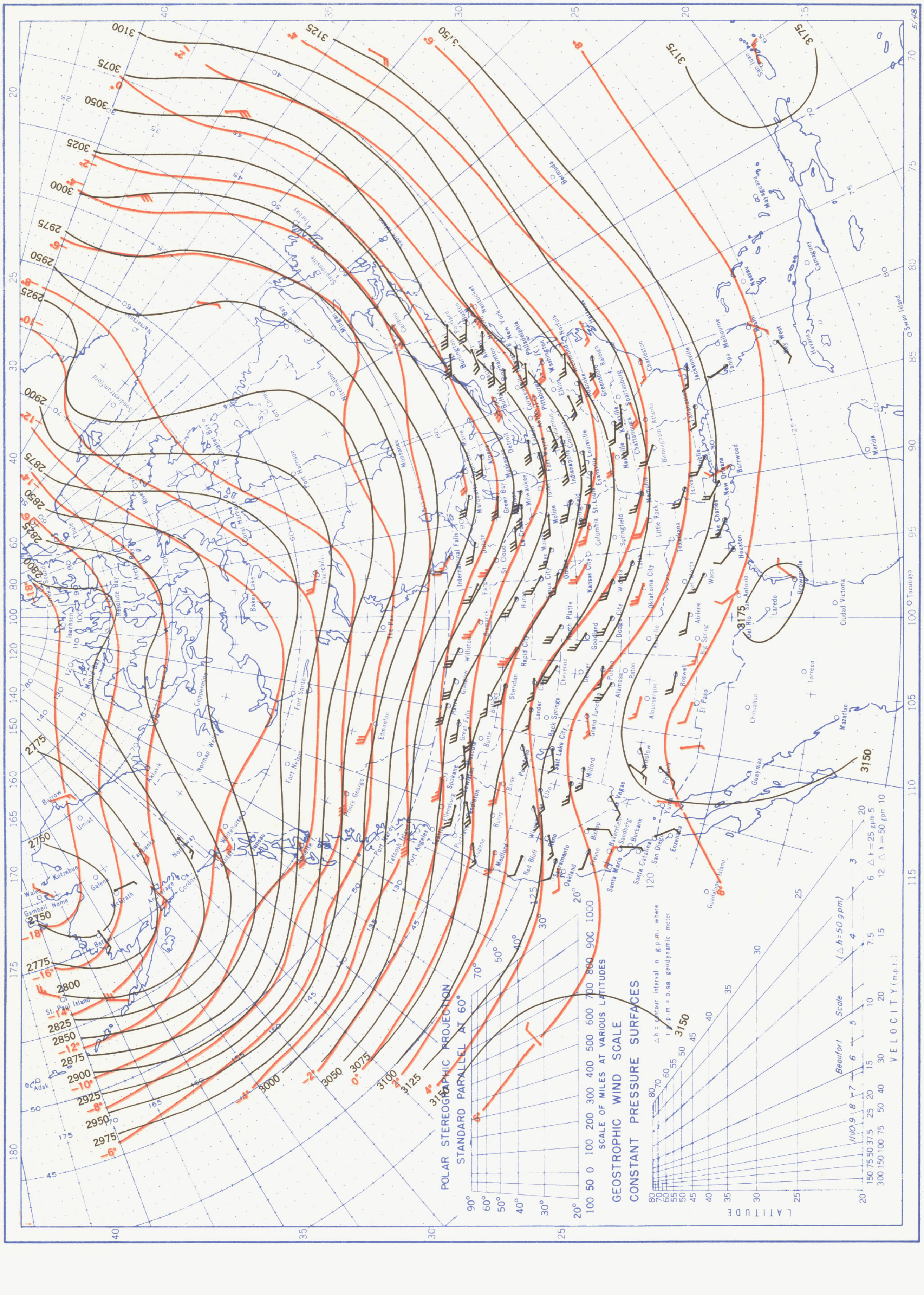
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), October 1955.



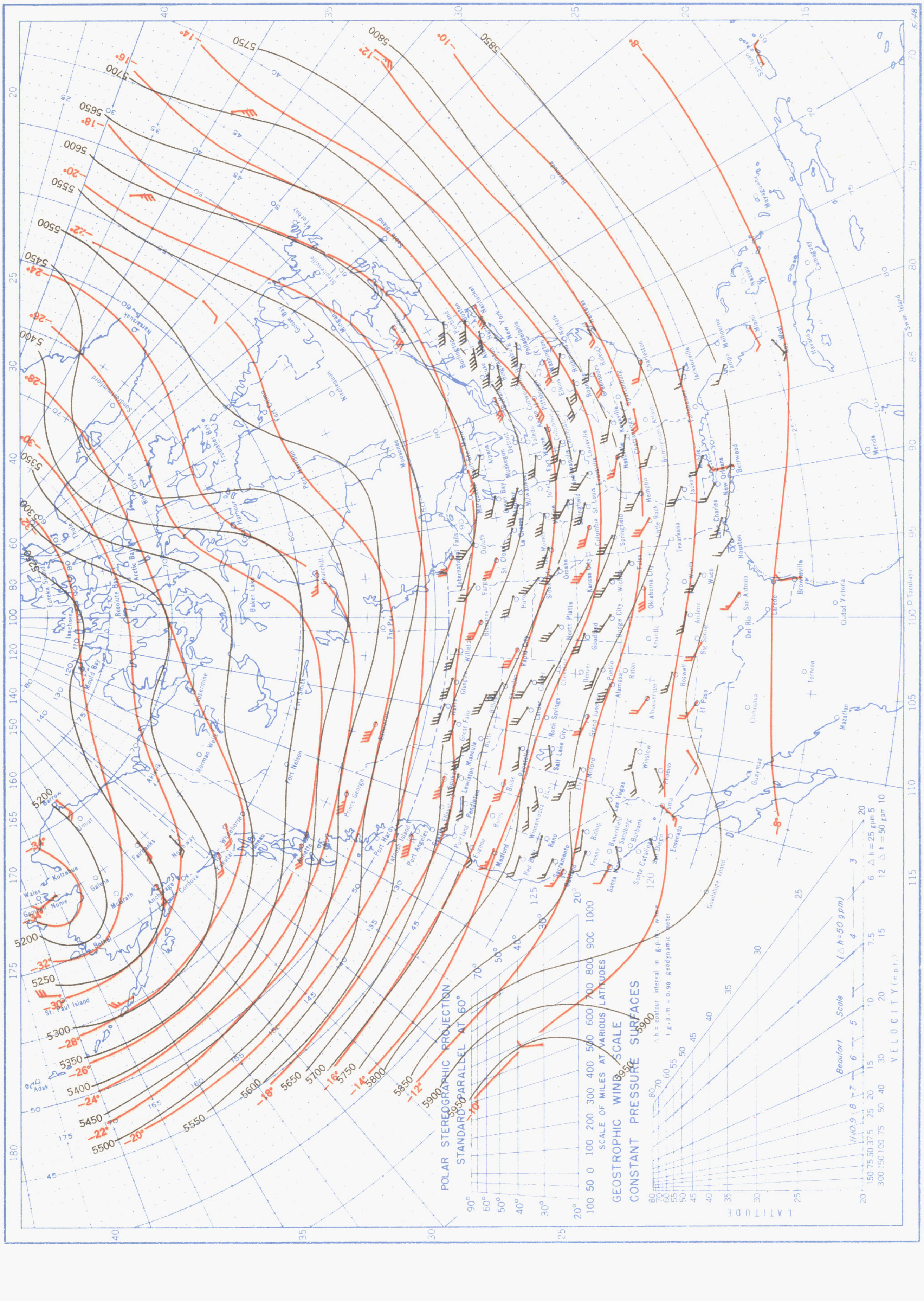
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), October 1955.



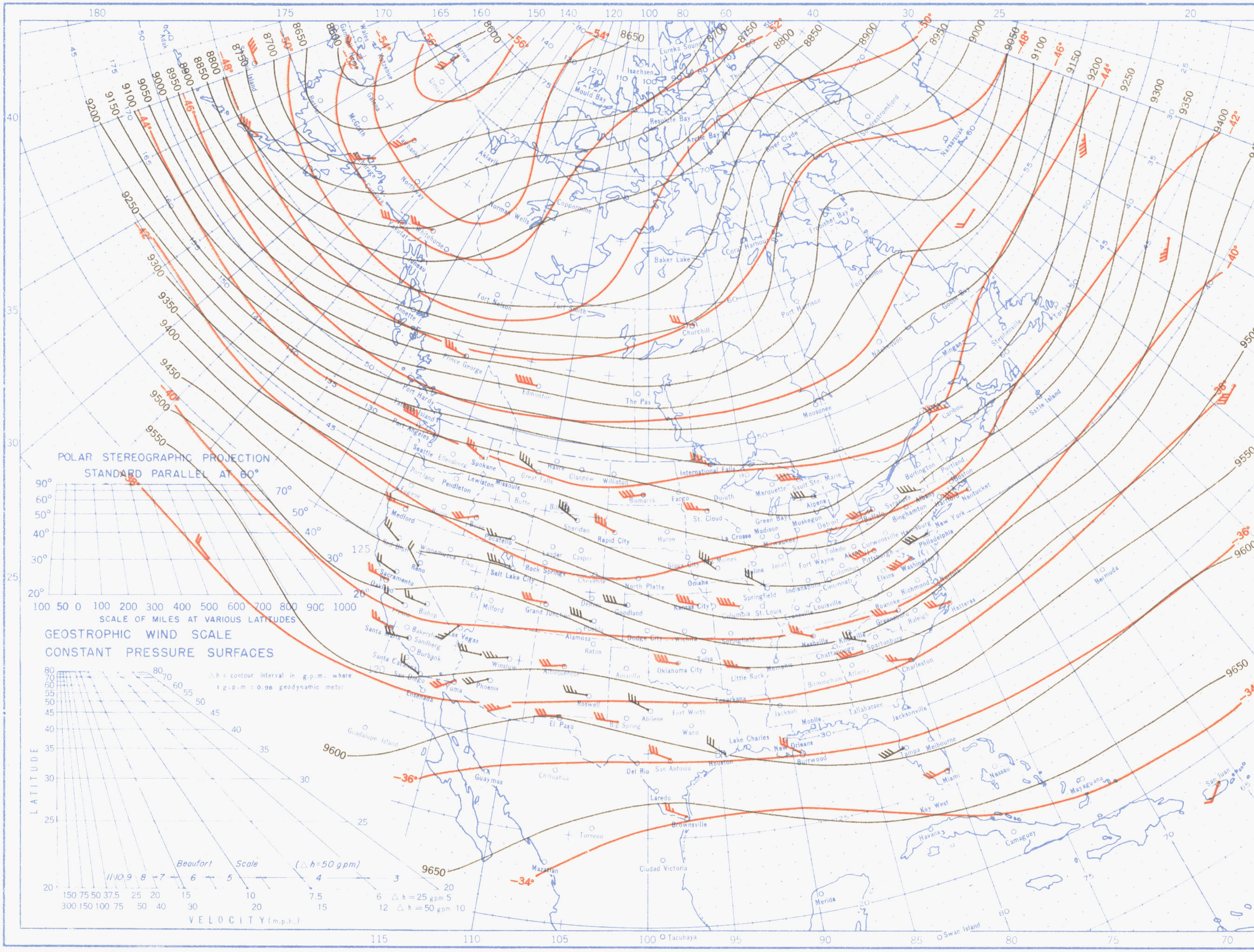
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), October 1955.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), October 1955.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.